Title: Fuels for Tomorrow/Today?

Brief Overview:

Alternative fuels have been proposed for several years to replace fossil fuels used today. Due to the cost and availability of these fuels much research in this area is being encouraged. Different fuels possess different heat contents and subsequently are capable of generating different amounts of energy. While this is certainly not the only criteria for selection as a fuel, it is an important one. This activity demonstrates the difference in heat content of two organic compounds and is representative of a simple method for making the determination. The student will be given a specific substance, wax and ethanol and asked to determine the heat of combustion of each. Students will collect data on the temperature change that occurs when a specific amount of the fuel is burned. Using the collected data and the TI-83, students will analyze the experimental data and pooled class data. Students will also compare the heats of combustion of the two substances and make predictions to determine which one would be the better fuel. They will also make suggestions about the advantages of using one of them as a fuel.

Links to NCTM 2000 Standards:

- **Content Standards**

Number and Operations
Students will understand the importance of significant digits, precision, and estimation.

Measurement
Students will employ a variety of measuring techniques and tools. Proper units and labeling will be stressed.

Data Analysis, Statistics, and Probability
Students will collect and analyze data using the TI-83 calculator and the Calculator Based Laboratory (CBL). Data can be transferred between the TI-83 and a desktop computer for enhanced analyzes and printing if desired. Students will be expected to draw conclusions from their analyzes and to extrapolate to situations not observed.

- **Process Standards**

Problem Solving
Students will learn the appropriate methods involved in, and the uses, of experimentally gathered data and pooled class data. They will develop strategies to interpret the data collected. Students also will use their observations to generalize solutions, and as an aid, in predicting future outcomes.

Reasoning and Proof
Students will be asked to make conjectures based on their individually collected data. They will use pooled class data and class observations to validate their conjectures. Students will use reasoning to analyze differences and similarities in pooled data.

Communication
Students will work in teams to collect, organize, pool, and analyze their data. Whole class discussions and data pooling will be an integral part of the lesson. The importance of communicating ones solution processes both orally and in writing will be emphasized throughout.

Connections
Students will explore the relationships between science and mathematics through experimental collection, statistical analyses, and visual representation of scientific data. A variety of mathematical concepts, topics and techniques will be encountered throughout the unit.

Representation
Students will use tabular, graphical, and functional representations of data and examine their connections. They will learn the appropriate uses of each representational method and examine their inherent strengths and weaknesses.

Links to Maryland High School Mathematics Core Learning Goals:

Functions and Algebra

- **1.1**
  Students will analyze patterns and functional relationships using the language of mathematics and appropriate technology. (**1.1.1,1.1.2**)
- **1.2**
  Students will model and interpret real world situations, using the language of mathematics and appropriate technology. (**1.2.1**)

Data Analysis and Probability

- **3.1**
  Students will collect, organize, analyze, and present data. (**3.1.1,3.1.2,3.1.3**)
  They will apply the basic concepts of statistics and probability to predict possible outcomes of real-world situations. (**3.2.1,3.2.2**)

Links to National Science Education Standards:

- **Unifying Concepts and Processes**
  Students will demonstrate an understanding of chemical systems**,** procedural order and organization of procedures and data. They will gather evidence of a physical process, model the results mathematically, and use both to explain the reaction.

- **Science as Inquiry**
  Students will develop abilities in scientific inquiry to include, data collection, constructing and reading graphs, statistical analysis, and the care/handling of lab equipment.

- **Physical Science**
  Students will learn about the structure of atoms and the structure and properties of matter.

- **Science and Technology**
  Students will develop an understanding of science and technology and will demonstrate an ability in both.

Links to Maryland High School Science Core Learning Goals:

- **Concepts of Chemistry**
  4.1
  Students will explain how the observation of the property of matter forms the basis for understanding its structure and changes in its structure.

  4.2
  Students will explain that all matter has structure and the structure serves as the basis for the properties of, and the changes in, matter. (**4.2.1,4.2.3,4.2.4**)

  4.6
  Students will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology. (**4.6.2**)

Grade/Level:

Grades 10(Honors)-12, Algebra I / Algebra II/ Pre-Calculus, Chemistry

Duration/Length:

This activity should take two days. The time is based on 45-50 minute periods.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Using the CBL
- Using TI-83 calculator
- Basic statistics (e.g. mean, median, mode)
- Data collection
- Construction and reading of a graph
- Fuels and their chemical content
- Care and handling of lab equipment
- Calculating the heat content of solutions

Student Outcomes:

Students will:

- brainstorm methods for data collection and analysis.
- work cooperatively in groups to collect and organize data using the TI-83, CBL, and pH probe.
- produce graphs of collected data using the TI-83.
- analyze data with the TI-83.
- participate in a discussion on observed results.
- relate experimental results to real world situations.

Materials/Resources/Printed Materials:

- CBL System
- TI-83 Graphing Calculator with CHEMBIO software
- Vernier Temperature Probe
- Vernier adapter cable
- TI-Graph Link
- Paraffin
- Ethanol (alcohol lamp)
- Candle + baby food jar lid for support
- Small aluminum can (beverage can without top works)
- 1 Utility clamp and slit stopper
- Matches
- Ring stand and 4-inch ring
- 2 stirring rods

Development/Procedures

1. Wear goggles.

2. Plug the temperature probe into the adapter cable in Channel 1 of the CBL. Use the link cable to connect the CBL to the TI Graphing Calculator. FIRMLY press in the cable ends.

3. Turn on the CBL and the calculator. Start the CHEMBIO program and proceed to the MAIN MENU.

4. Set up the calculator and CBL for one temperature probe and a temperature calibration.

    - Select SET UP PROBES from the main menu.
    - Enter "1" as the number of probes.
    - Select "TEMPERATURE from the SELECT PROBE menu.
    - Enter "1" as the channel number.
    - Select USE STORED from the CALIBRATION menu.

5. Set up the calculator and CBL for data collection.
   - Select COLLECT DATA from the MAIN MENU.
   - Select TIME GRAPH from the DATA COLLECTION menu.
   - Enter "5" as the time between samples, in seconds.
   - Enter "99" as the number of samples (data collection will be 8.25 minutes)
   - Press *ENTER*. Select USE TIME SETUP to continue.
   - Enter "0" as the minimum temperature (Y min).
   - Enter "100" as the maximum temperature (Y max).
   - Enter "10" as the temperature increment (Y scl).
   - DO NOT press enter to begin collecting data until step 12.

PART 1 CANDLE (**Paraffin**)

6. Secure a candle to a baby food lid with melted wax.

7. Mass the candle and lid and record.

8. Mass the empty can and record.

9. Add 100 mL of cool water to the can. (Use 200 mL in Part 2)

10. Mass the can plus the water and record.

11. Set up the apparatus as shown on page 7. Suspend the can about 5 cm above the wick. Use a utility clamp and slit stopper to suspend the temperature probe about halfway down in the water. Wait about 30 seconds before beginning the next step.

12. Press *ENTER* on the calculator to begin data collection. Monitor temperature in Celsius degrees on the CBL screen for about 30 seconds and record the initial temperature of the water as t_1, in your data table. Light the candle.

13. While stirring the water, heat the water until it reaches 40 ^{o}C and the put out the flame. *CAUTION: Keep hair and clothing away from the open flame.*

14. Continue stirring the water until the temperature stops rising. Record this maximum temperature as $t_{2.}$ When data collection is completed "DONE" appears on the CBL.

15. Determine and record the final mass of the cooled candle and lid. (or the cooled alcohol burner in Part 2.

16. Press *ENTER* to display a graph of temperature (y-axis) vs. time. Move the cursor along the line to examine the data points and confirm your recorded temperatures. As you move the cursor right or left, the time and temperature values will be displayed below the graph.

PART 2 ETHANOL

17. Press *ENTER* and choose YES to repeat the data collection using the ethanol alcohol burner. Repeat steps 7 – 16 using **200** mL of cool water.

Assessment:

- Before data collection students need to be familiar with the difference between heat content and temperature. A review of how to calculate heat content, q, would be helpful for advanced students. After the data collection students could be asked to graph by hand a set of representative data which could be researched on the Internet.
- One assessment could be to give the students sample data and let them graph it on the calculator. During the second part of the activity students collect pooled data and construct a scatter plot transferring from the calculator to the worksheet. The teacher could assess the accuracy, appropriate labeling, and pattern.

Extension/Follow Up:

- Students could research the type of fuels stored in their area and their usage.
- A more detailed discussion on the significance of multiple trials versus pooled group data. Statistical analyses including measures of central tendency and dispersion could be included.
- Students could research the use of alternative fuels in the automotive industry.

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NOTE:
This is an adaptation of a lab found in Chemistry with CBL by Vernier Software.